visible. The bands are, however, faint and dim, but are larger now, and the spectrum is similar to that observed on August 21.

1890, *November* 1.—Normal III. type, and about 6·8 mag. The bands are well seen in all parts of the spectrum. Bands 7 and 8 are especially broad.

R Aurigæ: 1890, *August* 18.—Mag. 7·2; colour fine rose-red. Very fine III. type, and the spectrum appears to resemble that of *Mira* rather than *R Andromedæ*.

R Andromedæ: 1890, *August* 23.—Magnitude 7·3 ±. Bands not deep, except in the blue and violet. Bringing the spectrum to a line, several bright lines in the violet and ultra-violet suspected. F possibly bright, but not sure about this.

1890, *September* 8.—The star has increased in light, and γ *Hydrogen* and F certainly seen, but still faint.

1890, *September* 14.—Bands in the red well seen, the yellow bands faint. F very plain now.

1890, *September* 15.—The F line now a wonderful spectacle. The star is not so red, the bands are generally faint except in the red. A bright space in the yellow looks like a mass of fine bright lines. A deep band in the violet. $H\gamma$ and D_3 possibly bright.

Comparative Photographs of the High Sun and Low Sun Visible Spectra, with Notes on the Method of Photographing the Red End of the Spectrum. By Frank McClean, M.A.

The accompanying photographs represent the High Sun and the Low Sun visible spectra from (H) to (A). The High Sun spectrum has been taken, as far as possible, when the Sun's altitude was over 45°, and the Low Sun spectrum when it was under $7\frac{1}{2}$°. The depth of atmosphere traversed for the Low Sun spectrum was thus about five times that traversed for the High Sun spectrum. A few exceptions to this rule are indicated in the accompanying Table. The elastic force of aqueous vapour in the atmosphere when each photograph was taken is given in the same Table.

The photographs are in sections numbered from I. to XIII. From I. to XI. they correspond to the divisions of Ångström's chart. The scale is also about the same, but in the photographs it varies as the secant of the angle through which the grating is turned from its central position. There is a slight break in the scale between Sections IV. and V., owing to a different object-glass being employed for the violet portion of the spectrum.

The corresponding sections of the High Sun and Low Sun spectra are mounted in juxtaposition, so as to show by comparison the atmospheric groups of lines. These groups divide themselves, on inspection, into two classes. Firstly, those in which the bulk of the lines grow uniformly darker as the Sun

approaches the horizon. Secondly, those in which many of the lines become exceptionally prominent under the same circumstances, and especially when there is much moisture in the air.

To the first class belong the groups (A) (a) and (B). To the second class belong the group about (C) and (β) above it, the group called (α) by Ångström, or (C_6) by Brewster and Gladstone; the rain-band group below and about (D), and the group (δ) above (D). Also two small groups called (ς) and (ι) by Brewster and Gladstone, situated near wave-lengths 5430 and 5040. The remaining bands indicated by Brewster and Gladstone are not easily distinguishable. Indications of groups of fine atmospheric lines exist in the region of (H), but this appearance may partly be caused by the weakness of the Low Sun spectrum. Weakness in the light of the spectrum affects the photographs in much the same way as strength in the lines. In some of the groups, the fainter solar lines appear weaker in the Low Sun spectrum than in the High Sun. This indicates that the stronger lines are also shown less strong than they should be, in the Low Sun spectrum.

The moderate scale of the photographs has some advantages. The photographs thus represent the well-known features of the solar spectrum in the compact form in which they are familiar. They constitute a companion to Ångström's chart, and can be directly compared with any part of it, and the lines due to the various substances identified from it. Also corresponding photographs of the metallic spectra can be obtained by means of the induction spark, as is shown by the photographs of the iron and the iridium spectra, laid before the Society in May 1888. The main divisions of the scale of wave-lengths have been placed on the photographs from Ångström's chart. The photographs, however, are not suitable for determining any principal measurement. They are only suitable for the identification of groups of lines, and for filling in the details between standard lines, whose wave-lengths have been determined by direct observations with proper instruments.

The photographs are enlarged about $8\frac{1}{2}$ times from the original negative.

The following are a few particulars of the instruments and methods employed for obtaining the photographs, and more especially those of the red end of the spectrum.

The spectroscopic apparatus is that which the writer has made use of with little change since 1879, with a large Rutherfurd grating which he then obtained. During the present year he has substituted a Rowland plane grating for the Rutherfurd, and these photographs are taken with it.

A fixed heliostat, commanding a large extent of true horizon, reflects the solar light into a telescope fixed parallel to the polar axis. The object-glass of this telescope is 98 inches in focal length, and it is stopped down to 4 inches aperture. Near its

focus a right-angled prism reflects the solar image horizontally into the spectroscope.

The spectroscope consists of collimating and observing telescopes of 2 inches aperture each, and respectively of 50 and 36 inches focal lengths.* These are fixed at an inclination of 16° 30′ to one another, and at their intersection the grating rotates horizontally. The positions of the grating for the different sections of the spectrum are given in the Table appended. The dispersion is double the corresponding rotation.

There are two important points with respect to the method of obtaining the photographs of the spectrum. These are, the selection of the absorption screens, and the preparation of the plates.

In the present case, for the purposes of absorption, use is made of glass cells one-sixth of an inch thick. These are filled with suitably coloured solutions, and placed on a stand in front of the slit. The colour can be chosen, not only to exclude the overlapping spectra, but also, by its variable absorption, to equalise, to some extent, the variable actinic force of the section to be photographed.

Many different dyes answer the purpose, but the following scheme will be found simple and effective for photographing the 2nd order spectrum :—For Sections I. and II., no screen.

For Sections III. to VII., a solution of 1 part of esculin in 2,000 water, with a trace of carbonate of ammonia. For Sections VIII. to XIII., 1 part of aurine in 600 of water.

Some variations of these, however, are of advantage in order to equalise the actinic force. For Section III., 1 of sulphate of quinine in 400 water, with a trace of sulphuric acid. For Section IV., 1 of chloride of copper in 12 of water. For Sections VIII. and IX., 1 of aniline orange in 3,000 of water. Changes in strength may also be made.

In case the overlapping spectrum of the 3rd order has to be photographed, there may be used—For Sections VII. and VIII., 1 of methyl blue in 15,000 of water. For Sections IX. to XIII., 1 of chloride of copper in 3 of water.

Mawson and Swan's lantern and photo-mechanical plates have been found most suitable for the work, on account of their hardness and freedom from grain. They have been employed by the writer for the photography of the spectrum since 1887. For Sections I. and II. they are used as they are. For Sections III. to VI. they are prepared with erythrosine; and for Sections VII. to XIII. they are prepared with cyanin and ammonia.

The erythrosine plates present no difficulties. A bath is prepared of $2\frac{1}{2}$ ounces of water, and 6 minims of 1 erythrosine in 100 water. The plate is first placed in water for one minute, then in the erythrosine bath for one minute, and again in water for one minute. It is afterwards dried slowly in the drying-box.

* The alternative object-glass for use with the violet end of the spectrum is of 38 inches focal length.

The colour of the plate should be almost imperceptible, or otherwise the plate will fog in development.

The preparation of the cyanin plates is based on Schumann's formula as given in Vogel's Manual, published by Gauthier, 1887. A much larger proportion of alcohol is required to keep the plates free from specks of cyanin, a larger proportion of ammonia is necessary to make anything of the extreme red spectrum, and a smaller proportion of cyanin must be used to avoid overcolouring the plates.

For the preparation of the plates, baths are prepared as follows:—

No. 1. 1 oz. methylated alcohol.
35 minims of ammonia (full strength).
$1\frac{1}{2}$ ozs. of water.

No. 2. 1 oz. methylated alcohol.
8 minims solution of cyanin, 1 in 500 alcohol.
35 minims ammonia.
$1\frac{1}{2}$ ozs. water.

Both baths are brought to a temperature of about 65° Fahrenheit.

The plate is put in No. 1 for 45 seconds, then in No. 2 for 60 seconds, and again in No. 1 for 45 seconds. This treatment keeps the plate of an even colour. The colour of the plates must be almost imperceptible, or they will fog. The best developer is that recommended by the makers for the photo-mechanical plates, with, for the extreme red spectrum, an extra quantity of ammonia. Should the plates show a tendency to fog, a preliminary bath of weak preservative (metabisulphite of potash) for from 20 to 40 seconds is of marked advantage.

Samples of cyanin vary exceedingly. That used as above was obtained through Messrs. Griffin & Co. from a manufacturer in Dublin.

Cyanin plates deteriorate with keeping, especially along the margin. They are at their best for three or four days after preparation, but remain quite fit for use for a fortnight. A better result might be expected, if a good substitute for cyanin could be found that would work without ammonia.

On a bright day the exposures required in the way described are:—For Sections I. to VII., varying up to 2 minutes. For VIII. to XIII., varying from 2 to 20 minutes. For the Low Sun spectrum 2 or 3 times this exposure is necessary.

A set of negatives of the whole spectrum are placed before the meeting. They are not, however, the best negatives selected for enlargement.

Some idea of the minute detail attainable on the negatives may be gathered from an inspection of the negative of No. 1 section under the microscope. The field of view covers about one-eighth of an inch, and in that space over eighty well-defined lines in characteristic groups may be counted. Some of these

lines are spaced 1000 to the inch, and correspond to an angular dispersion of 5 seconds.

This negative, however, is taken on an unprepared plate, and the same minuteness of detail has not been obtained with the plates when dyed. That such definition can be obtained throughout, is shown by some photographs of fragments of the spectrum recently presented to the Society by Mr. Higgs. It is much to be desired that either he or Mr. Ranyard, who has described his work, would state by what photographic process such photographs of the spectrum are obtained.

The photographs are presented to the Society, and will be placed in the Library.

TABLE.

Section of Photograph.		Angle of Grating from Mean Position.	Mean H.S. Altitude.	Mean L.S. Altitude.	Elastic Force of Aqueous Vapour in inches of Mercury.
		° ′	°	°	
I.	H.S.	13 6	44	...	·39
	L.S.	"	...	9	·35
II.	H.S.	14 12	41	...	·35
	L.S.	"	...	7½	·39
III.	H.S.	15 18	44	...	·39
	L.S.	"	...	7	·46
IV.	H.S.	16 24	52	...	·39
	L.S.	"	...	7	·39
V.	H.S.	17 30	55	...	·46
	L.S.	"	...	3½	·26
VI.	H.S.	18 36½	46	...	·24
	L.S.	"	...	3	·37
VII.	H.S.	19 43	46	...	·29
	L.S.	"	...	3	·28
VIII.	H.S.	20 50½	55	...	·30
	L.S.	"	...	5	·37
IX.	H.S.	21 58¼	45	...	·24
	L.S.	"	...	7½	·37
X.	H.S.	23 6¼	46	...	·24
	L.S.	"	...	7½	·30
XI.	H.S.	24 14¼	52	...	·30
	L.S.	"	...	7	·23
XII.	H.S.	25 22¼	47	...	·37
	L.S.	"	...	7½	·26
XIII.	H.S.	26 10	60	...	·30
	L.S.	"	...	7	·20

Photograph of the A line in the Solar Spectrum.
By George Higgs.

(*Communicated by the Secretaries.*)

Where the eye begins to fail in ascending towards the more refrangible portions of the solar spectrum, the properties of the haloid salts of silver enable us to continue the thread of research, and in the opposite direction the photographic limits have from time to time been set back as our knowledge of organic chemistry has advanced, till the distinction between the chemical and thermal has ceased to exist. In spite of this, however, an examination of results seems to point to the fact that photography has been slow in adding to the information hitherto gained by eye-observation of such regions which lie on the less refrangible limits of the visible spectrum.

With a view to formulating some process for preparing dried emulsions which shall give certain and uniform results of a great degree of sensitiveness for this region I have for some time been engaged in investigating the properties, and in the preparation in a state of purity, of some of the salts of the anthracene series, an account of which I hope to furnish in its place (belonging as it does more to the domain of Chemistry than to that of Astronomy).

I herewith beg to submit to the notice of Fellows interested a copy of a portion of "Great A" from my Photographic Map of the Normal Solar Spectrum. In order to show as much detail as possible I have had to enlarge about ten diameters, or three times Ångström's scale. The "head" is seen to be composed of about 50 lines. Each line of the pairs composing the fluting or "tail" is a nebulous double. Between the pairs and commencing at w. l. 7622 are to be seen other pairs which are apparently harmonically related to the thicker nebulous pairs. The same region taken with a low Sun of about 86° to 88° zen. dis. exhibits the head as one broad band, disintegration commencing at w. l. 7595 and 7598·5.

Spectroscopic Notes and Queries. By the Rev. A. L. Cortie, S.J.

(*Communicated by E. W. Maunder.*)

I. Has D_3 a coincident dark line in the solar spectrum?

The position of this chromospheric line as given by Young in his list of bright lines is w. l. 5874·9. In some of the spectroscopic maps which I have consulted, dark lines are indicated differing by less than one-tenth metre from the position of the bright line. Ångström (1868) draws a telluric line at 5874·2, followed on the less refrangible side by a band of slight intensity terminated by a well-marked line at 5878·3. Fievez (1882),